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EXAMINER	
LUU, CUONG V	
ART UNIT	**PAPER NUMBER**
2128	

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Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No.	Applicant(s)	
	10/540,861	LEI ET AL.	
	Examiner	Art Unit	
	Cuong V. Luu	2128	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *27 June 2005*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-15* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1,14 and 15* is/are rejected.

7)☒ Claim(s) *2-13* is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *27 June 2005* is/are: a)☐ accepted or b)☒ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☒ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date *6/27/05, 10/3/05*.
4) ☒ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Claims 1-15 are pending. Claims 1-15 have been examined. Claims 2-13 have been objected to. Claims 1 and 14-15 have been rejected.

Drawings

1. Figure 1 should be designated by a legend such as --Prior Art-- because only that which is old is illustrated. See MPEP § 608.02(g). Corrected drawings in compliance with 37 CFR 1.121(d) are required in reply to the Office action to avoid abandonment of the application. The replacement sheet(s) should be labeled "Replacement Sheet" in the page header (as per 37 CFR 1.84(c)) so as not to obstruct any portion of the drawing figures. If the changes are not accepted by the examiner, the applicant will be notified and informed of any required corrective action in the next Office action. The objection to the drawings will not be held in abeyance.

2. The drawings are objected to as failing to comply with 37 CFR 1.84(p)(4) because reference characters "A, B, and C" have been used to designate different steps in both figures 1 and 3. Corrected drawing sheets in compliance with 37 CFR 1.121(d) are required in reply to the Office action to avoid abandonment of the application. Any amended replacement drawing sheet should include all of the figures appearing on the immediate prior version of the sheet, even if only one figure is being amended. Each drawing sheet submitted after the filing date of an application must be labeled in the top margin as either "Replacement Sheet" or "New Sheet" pursuant to 37 CFR 1.121(d). If the changes are not accepted by the examiner, the applicant will be notified and informed of any required corrective action in the next Office action. The objection to the drawings will not be held in abeyance.

Claim Rejections - 35 USC § 112

The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter, which the applicant regards as his invention.

Claim 2 is rejected under 35 U.S.C. 112, second paragraph.

3. Claim 2 is rejected under 35 U.S.C. 112, second paragraph, as being incomplete for omitting essential elements, such omission amounting to a gap between the elements. See MPEP § 2172.01. The omitted elements are steps that describe existence of convection, diffusion, and pressure gradient terms in the analysis step (E).

4. Claim 7 is rejected under 35 U.S.C. 112, second paragraph, as being incomplete for omitting essential elements, such omission amounting to a gap between the elements. See MPEP § 2172.01. The omitted elements are steps that describe existence of drag and lift force terms.

Claim Rejections - 35 USC § 101

35 U.S.C. 101 reads as follows:

> Whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefor, subject to the conditions and requirements of this title.

Claim 15 is rejected under 35 U.S.C. 101 because the claimed invention is directed to non-statutory subject matter.

5. As per claim 15, it is rejected for claiming a program, which is directed to a non-statutory subject matter.

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

Claims 1 and 14-15 are rejected under 35 U.S.C. 103(a) as being unpatentable over Hirt et al (Volume of Fluid (VOF) Method for the Dynamics of Free Boundaries, Journal of computational Physics, 1981), submitted by the Applicant, in view of Kela (Hierarchical Octree Approximations for Boundary Representation-Based Geometric Models, Computer Aided Design 21, 1989 July/august, No. 6, London GB).

6. As per claim 1, Hirt teaches a method for numerical analysis of a flow field of incompressible viscous fluid, directly using V-CAD data, comprising:

a analyzing step (E) of applying a cut cell finite volume method combined with a VOF method to a boundary of a flow field to analyze the flow field (p. 207 the second last paragraph).

However, Hirt does not teach:

a dividing step (A) of dividing external data into a plurality of cells (13) having boundaries orthogonal to each other, the external data including boundary data of an object which contacts incompressible viscous fluid;

a cell classifying step (B) of classifying the divided cells into an internal cell (13a) positioned inside or outside the object and a boundary cell (13b) including the boundary data;

a cut point determining step (C) of determining cut points in ridges of the boundary cell on the basis of the boundary data;

a boundary face determining step (D) of determining a polygon connecting the cut points to be cell internal data for the boundary face.

Kela teaches:

a dividing step (A) of dividing external data into a plurality of cells (13) having boundaries orthogonal to each other, the external data including boundary data of an object (p. 1 col. 2 of the page);

a cell classifying step (B) of classifying the divided cells into an internal cell (13a) positioned inside or outside the object and a boundary cell (13b) including the boundary data (p. 1 col. 2 of the page);

a cut point determining step (C) of determining cut points in ridges of the boundary cell on the basis of the boundary data (p. 4 figures 4-5 and paragraphs on col. 1-2);

a boundary face determining step (D) of determining a polygon connecting the cut points to be cell internal data for the boundary face (p. 4 figures 4-5 and paragraphs on col. 1-2);

It would have been obvious to one of ordinary skill in the art to combine the teachings of Hirt and Kela. Kela's teachings would have efficiently computed octree approximations from B-rep solids for motion planning such as fluid flow (p. 1 col. 1 1st paragraph).

7. As per claim 14, Hirt and Kela teach performing the limitations in claim 1 using computers, so they inherit a device for numerical analysis of a flow field of incompressible viscous fluid, directly using V-CAD data, comprising:

an input device (2) for inputting external data including boundary data of an object (1) that contacts incompressible viscous fluid;

an external storage device (3) for storing substantial data of shape data and physical property data integrated into each other, and a storage operational program for the substantial data;

an internal storage device (4) and central processing device (5) for executing the storage operational program; and

an output device (6) for outputting a result of the execution;

wherein the device divides the external data into a plurality of cells (13) having boundaries orthogonal to each other, classifies the divided cells into an internal cell (13a) positioned inside or outside the object and a boundary cell (13b) including the boundary data, determines cut points in ridges of the boundary cell on the basis of the boundary data, determines a polygon connecting the cut points to be cell internal data for the boundary

face, and applies a cut cell finite volume method combined with a VOF method to a boundary of a flow field to analyze the flow field.

8. As per claim 15, Hirt and Kela teach performing the limitations in claim 1 using computers, so they inherit a program for numerical analysis of a flow field of incompressible viscous fluid, directly using V-CAD data, causing a computer to perform:

a dividing step (A) of dividing external data into a plurality of cells (13) having boundaries orthogonal to each other, the external data including boundary data of an object which contacts incompressible viscous fluid;

a cell classifying step (B) of classifying the divided cells into an internal cell (13a) positioned inside or outside the object and a boundary cell (13b) including the boundary data; a cut point determining step (C) of determining cut points in ridges of the boundary cell on the basis of the boundary data;

a boundary face determining step (D) of determining a polygon connecting the cut points to be cell internal data for the boundary face; and

a analyzing step (E) of applying a cut cell finite volume method combined with a VOF method to a boundary of a flow field to analyze the flow field.

Allowable Subject Matter

Claims 2-13 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

The following is a statement of reasons for the indication of allowable subject matter:

9. As per claim 2, the prior art of record does not teach a method for numerical analysis of a flow field of incompressible viscous fluid, according to claim 1, the analyzing step (E) comprising:

applying a two-dimensional QUICK interpolation scheme to a convection term for space integral;

applying central difference having precision of a degree of a second order to a diffusion term;

combining the convection term and the diffusion term, and applying Adams-Bashforth method having precision of a degree of a second order to the combined convection term and diffusion term for time marching; and

applying an Euler implicit method having precision of a degree of a first order to a pressure gradient term for time marching.

10. As per claim 3, the prior art of record does not teach a method for numerical analysis of a flow field of incompressible viscous fluid, according to claim 2, wherein for a two-dimensional boundary cell, a governing equation in the finite volume method is expressed by a governing equation (7) of Formula 1,

[Formula 1]

$$\iint_{V_{i,j}} \frac{\partial \bar{u}}{\partial t} dV = -\iint_{V_{i,j}} div(\bar{u} \otimes \bar{u}) dV - \iint_{V_{i,j}} div(p\bar{I}) dV + \frac{1}{\mathrm{Re}} \iint_{V_{i,j}} div(grad(\bar{u})) dV$$

11. As per claim 4, the prior art of record does not teach a method for numerical analysis of a flow field of incompressible viscous fluid, according to claim 3, wherein the convection term,

the pressure gradient term and the diffusion term in the governing equation of the finite volume method are expressed by the equations (8), (9) and (10) of Formula 2, respectively,

[Formula 2]

convection term:

$$\iiint_{V_{i,j}} div(\vec{u}\otimes\vec{u})dV = \oiint_{S_{i-s}} (\vec{u}\otimes\vec{u})\cdot\vec{n}dS = \sum_{m=1-S} (\vec{u}\otimes\vec{u})_m \cdot \vec{n}\delta S_m$$
$$= [\Delta y(B_{i,j}u^{(x)}_{i,j}u_{i,j} - B_{i-1,j}u^{(x)}_{i-1,j}u_{i-1,j})$$
$$+\Delta x(A_{i,j}u^{(y)}_{i-1/2,j+1/2}v_{i,j} - A_{i,j-1}u^{(y)}_{i-1/2,j-1/2}v_{i,j-1})]\vec{i} \qquad (8)$$
$$+[\Delta y(B_{i,j}v^{(x)}_{i+1/2,j-1/2}u_{i,j} - B_{i-1,j}v^{(x)}_{i-1/2,j-1/2}u_{i-1,j})$$
$$+\Delta x(A_{i,j}v^{(y)}_{i,j}v_{i,j} - A_{i,j-1}v^{(y)}_{i,j-1}v_{i,j-1})]\vec{j} \,|\, only\ no-slip \quad on\ wall$$

pressure gradient term:

$$\iiint_{V_{i,j}} div(p\vec{I})dV = \oiint_{S_{i-s}} (p\vec{I})\cdot\vec{n}dS = \sum_{m=1-S} p_m\vec{I}\cdot\vec{n}\delta S_m$$
$$= \Delta y[B_{i,j}p_{i+1/2,j} - B_{i-1,j}p_{i-1/2,j} - p_p(B_{i,j} - B_{i-1,j})]\vec{i} \qquad (9)$$
$$+\Delta x[A_{i,j}p_{i,j+1/2} - A_{i,j-1}p_{i,j-1/2} - p_p(A_{i,j} - A_{i,j-1})]\vec{j}$$

diffusion term:

$$\iiint_{V_{i,j}} div(grad(\vec{u}))dV = \oiint_{S_{i-s}} grad(\vec{u})\cdot\vec{n}dS = \sum_{m=1-S} grad(\vec{u})_m \cdot \vec{n}\delta S_m$$
$$= [\Delta y(B_{i,j}grad(u)^x_{i+1/2,j} - B_{i-1,j}grad(u)^x_{i-1/2,j} - (B_{i,j} - B_{i-1,j})grad(u)^x_p)$$
$$+\Delta x(A_{i,j}grad(u)^y_{i,j+1/2} - A_{i,j-1}grad(u)^y_{i,j-1/2} - (A_{i,j} - A_{i,j-1})grad(u)^y_p)]\vec{i} \qquad (10)$$
$$+[\Delta y(B_{i,j}grad(v)^x_{i+1/2,j} - B_{i-1,j}grad(v)^x_{i-1/2,j} - (B_{i,j} - B_{i-1,j})grad(v)^x_p)$$
$$+\Delta x(A_{i,j}grad(v)^y_{i,j+1/2} - A_{i,j-1}grad(v)^y_{i,j-1/2} - (A_{i,j} - A_{i,j-1})grad(v)^y_p)]\vec{j}$$

12. As per claim 5, the prior art of record does not teach a method for numerical analysis of a flow field of incompressible viscous fluid, according to claim 3, wherein when a no-slip boundary condition is used for a solid boundary, integral is performed on the solid boundary

with the convection term being zero, a value of a middle point P of a cut line segment being used as an average for the pressure gradient term and the diffusion term, and a space integral is performed with areas fractions being applied to all of the terms.

13. As per claim 6, the prior art of record does not teach a method for numerical analysis of a flow field of incompressible viscous fluid, according to claim 3, wherein the boundary cell having the parameter smaller than a threshold value of VOF=0.01 is regarded as a complete solid, for the boundary cell having the parameter larger than the threshold value, a definition point for the parameter calculated in a cut cell is set at a center of the boundary cell, and a definition point for a parameter in a ridge is set at a center of a cell ridge, and a parameter at a middle point of a line segment 4 is calculated by a linear interpolation.

14. As per claim 7, the prior art of record does not teach a method for numerical analysis of a flow field of incompressible viscous fluid, according to claim 3, wherein a drag force (in a flow direction) and a lift force (in a direction vertical to the flow) acting on the object are expressed by equations (12) and (13) of Formula 3,

[Formula 3]

drag force:

$$F_x = F_D = \iint_V \left(\frac{\partial \sigma_{xx}}{\partial x} + \frac{\partial \sigma_{xy}}{\partial y}\right) dxdy$$

$$= \iint_V \left(\frac{\partial \sigma_{xx}}{\partial x}\right) dxdy + \iint_V \left(\frac{\partial \sigma_{xy}}{\partial y}\right) dydx = \oint_S \sigma_{xx} ds + \oint_S \sigma_{xy} ds \qquad (12)$$

$$= \int_{y_1}^{y_2} (\sigma_{xx}|_{f_1(y)} - \sigma_{xx}|_{f_2(y)}) dy + \int_{x_1}^{x_2} (\sigma_{xy}|_{g_1(x)} - \sigma_{xy}|_{g_2(x)}) dx \Big|_{\text{only Cartesian}}$$

lift force:

$$F_y = F_L = \iint_V (\frac{\partial \sigma_{yx}}{\partial x} + \frac{\partial \sigma_{yy}}{\partial y}) dxdy$$

$$= \iint_V (\frac{\partial \sigma_{yx}}{\partial x}) dxdy + \iint_V (\frac{\partial \sigma_{yy}}{\partial y}) dydx = \oint_S \sigma_{yx} ds + \oint_S \sigma_{yy} ds \qquad (13)$$

$$= \int_{y_1}^{y_2} (\sigma_{yx}|_{f_1(y)} - \sigma_{yx}|_{f_2(y)}) dy + \int_{x_1}^{x_2} (\sigma_{yy}|_{g_1(x)} - \sigma_{yy}|_{g_2(x)}) dx \Big|_{only\ Cartesian}$$

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Cuong V. Luu whose telephone number is 571-272-8572. The examiner can normally be reached on Monday-Friday 8:30am-5:00pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Kamini Shah, can be reached on 571-272-2279. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300. An inquiry of a general nature or relating to the status of this application should be directed to the TC2100 Group receptionist: 571-272-2100.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

CVL

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